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JOINT AIRSPACE MANAGEMENT: A COMBAT MULTIPLIER

BY

LIEUTENANT COLONEL ROBERT M. STEWART  
United States Army

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JOINT AIRSPACE MANAGEMENT: A COMBAT MULTIPLIER

AN INDIVIDUAL STUDY PROJECT

by

Lieutenant Colonel Robert M. Stewart  
United States Army

Colonel John E. Freilino  
Project Advisor

U. S. Army War College  
Carlisle Barracks, Pennsylvania 17013

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## ABSTRACT

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## INTRODUCTION

Efficient management and control of the airspace above a theater of operations is a combat multiplier. Without airspace management commanders cannot maximize combat power, cannot carry out the tenants of AirLand Battle doctrine, and may lose assets through fratricide. All services use the airspace, whether it is by aircraft, artillery, missiles, remotely piloted vehicles, or air defense artillery. Not only is each service a user of the airspace, but each has developed their own set of rules governing operations within that airspace. Increased demands placed on the Department of Defense and the armed forces of the United States dictate that future operations must be joint. It is critical that joint doctrine not only be developed, but that this doctrine takes advantage of the strengths of each service.

The intent of this paper will be to study the existing joint and service doctrine, then analyze each service's airspace management system. From that study an analysis will be made of each system's ability to support a joint force. Conclusions will be drawn and recommendations made on any potential shortcomings. Since this study is being conducted at the U.S. Army War College, there will be a greater emphasis on the application of airspace doctrine to Army operations.

## BACKGROUND

Do we need to worry about airspace management at all? FM 100-5 states "Airspace coordination maximizes joint force effectiveness without hindering the combat effectiveness of either service. '. . .' To be simple and flexible, our airspace coordination system operates under a concept of management by exception. '. . .' All airspace management rules and procedures will be standardized to the extent possible, '. . . .'" There have been many studies and articles written about airspace management. There is obviously a great deal of concern and a lack of understanding about the present system. Major General Ostavich, the Commander of the U.S. Army Aviation Center, was quoted in 1986 as saying "Army Airspace Command and Control (A2C2) '. . .' As long as I have been involved with it, Army Aviation has been totally ignorant on these matters<sup>2</sup>." There have been two excellent U.S. Army War College Military Study Program papers written on Army Airspace Management. The first by LTC Chambers, Aviation Liaison Officers: A Means to Enhance Combat Power, addresses the need for aviation liaison officers with maneuver units. The second by LTC Cross and LTC Nelson, Adequacy of the Army Airspace Command and Control System on the AirLand Battlefield, addresses personnel, training, doctrine, equipment, and leadership shortfalls at the Brigade level.

History gives us the following examples of the need for airspace management;

a. World War II. Operation "HUSKY", the invasion of Sicily in November 1942, was planned to include an airborne assault to support the amphibious landing on the southern side of the island. The operation included naval gunfire support and Air Force tactical bombing. The routes aircraft carrying the airborne assault planned to use had been extensively coordinated by General Ridgway. Despite this, during the assault both allied ground and sea antiaircraft fire engaged the C-47's and the result was a disaster. Almost 42% of the 145 aircraft were hit. Of those hit, 23 did not return. The investigation that followed determined despite coordination gunners thought the aircraft were low flying Axis bombers or a German airborne assault<sup>3</sup>.

b. Arab-Israeli Wars. During the 1973 war the Egyptians surprised the Israeli's with their modern and effective air defense system. During the war the Israeli's lost 102 aircraft, 50 were lost in the first three days. The Egyptian air defense system was so effective the army was able to accomplish both tactical and operational objectives. Substantial setbacks were only suffered when they ventured out from under the air defense protection. The price the Egyptians and Syrians paid was a loss of 514 aircraft of which 58 were shot down by their own forces. Over a 10% loss to fratricide by ineffective airspace management<sup>4</sup>.

c. Grenada. During the invasion of Grenada in October 1983, the United States faced a multitude of airspace management problems that directly effected the execution of the operation.



Delays in the arrival of troops and supplies were caused by "intense air traffic control problems over Salinas. ' . . . ' aircraft were often stacked up to the ionosphere<sup>5</sup>." A Navy A-7 attack aircraft improperly identified a target and fired into an 82nd Airborne Division Brigade command post causing substantial casualties. Neither the designated controlling headquarters nor the approved contingency plans were used. After-action reports listed "air assets not always properly controlled and the lack of understanding of interservice close air support procedures" as serious problems<sup>5</sup>.

These examples show the adverse effect of poor airspace management on the outcome of combat operations. The military has spent an enormous amount of time writing about the use of airspace and creating doctrine that will effectively manage it. The manuals for each service that directly address doctrine are listed below with their dates of publication.

- a. AF Manual 2-7: Tactical Air Force Operations-Tactical Air Controller System (TACS), 2 February 1979.
- b. AF Manual 2-12: Airspace Control in the Combat Zone, 22 August 1988.
- c. FM 1-103: Airspace Management and Air Traffic Control in a Combat Zone, 30 December 1981.
- d. FM 100-28: Doctrine and procedures for Airspace Control in the Combat Zone, 1 December 1975.
- e. FM 100-42: U.S. Air Force/U.S. Army Airspace Management in an Area of Operations, 1 November 1976.

f. FM 100-103: Army Airspace Command and Control in a Combat Zone, October 1987.

g. FMFM 5-1: Marine Aviation, 24 August 1979.

h. NWP 22.2: Supporting Arms in Amphibious Operations, undated.

This list includes only those manuals that deal solely or in part with airspace management. The bibliography contains many more manuals that discuss the subject. It is important to note that as one goes through the different publications, doctrine is consistent. No discrepancies in the doctrine appear between manuals, which in itself is significant.

#### JOINT DOCTRINE

The requirement for joint doctrine on airspace management has existed for years. It is presently addressed in the 1975 multi-service manual entitled Doctrine and Procedures for Airspace Control in the Combat Zone<sup>7</sup>. This manual remains the current doctrine but will be replaced by JOINT PUB 3-52, Doctrine for Joint Airspace Control in a Combat Zone. This is a Draft TEST PUB dated 6 November 1990 and is an excellent manual that will help tie together the doctrine published by the individual services. It is written to "provide broad doctrinal guidance" and is indicative of the new role the Joint Staff is playing since the Goldwaters-Nichols Act became law<sup>8</sup>.

There are several important parts of JOINT Pub 3-52 that need to be discussed. The manual is directed at joint forces

involved in the use of airspace over a combat zone. The intent is to provide commanders a basic framework upon which to build an airspace control system for a joint operating area. From this framework there should be compatibility and interoperability among the different services' systems.

Airspace control is defined as "coordinating, integrating and regulating airspace to increase operational effectiveness by promoting the safe, efficient and flexible use of airspace". The key to efficient and flexible use lies in a system that allows all services to operate their various weapon systems without restricting available combat power<sup>10</sup>. There are several problems associated with restricting weapons. The first is there must be a system or means to identify effectively aircraft and missiles as friendly or hostile. The second and more difficult problem is building a system that will integrate the land battle. This includes "surface force operations, supporting fires, supporting air operations, air defense operations, special operations, and airspace control activities<sup>11</sup>."

JOINT PUB 3-52 emphasizes that the airspace of the modern battlefield will be joint and there must be a degree of standardization between the services. This will include both doctrine, procedures, terms, and hardware.

The doctrine in JOINT PUB 3-52 is built on unity of command in order to gain an integrated system. The following individuals and their roles comprise this unity of command:

Joint Force Commander (JFC): The JFC commands and controls all assigned and attached forces. He is responsible for the employment of forces to accomplish assigned objectives. Key is the development of priorities and objectives, because they drive all the plans for subordinate units, including the airspace coordination plan.

Joint Force Air Component Commander (JFACC): The JFACC is normally designated by the Joint Force Commander. He also will normally be the service component commander providing the majority of the air assets in the force structure and, more importantly, the one with the necessary command and control system.

Airspace Control Authority (ACA): The Joint Force Commander designates the Airspace Control Authority. The ACA establishes an airspace control system that will be responsive to the mission of the joint force. Usually the ACA is also the JFACC. The ACA publishes an Airspace Control Plan (ACP) that is implemented and updated through an Airspace Control Order (ACO).

Area Air Defense Commander (AADC): Designated by the JFC and is normally also the Joint Force Air Component Commander. He is responsible for the integration of air defense systems over both land and the sea<sup>12</sup>.

The key to the effective control of the airspace is placing responsibility for coordinating all airspace users under one individual. The Joint Force Air Component Commander does not assume operational control of assets, but is responsible for the

coordination and synchronization of these assets. The primary tool is the Airspace Control Plan and the Air Tasking Order.

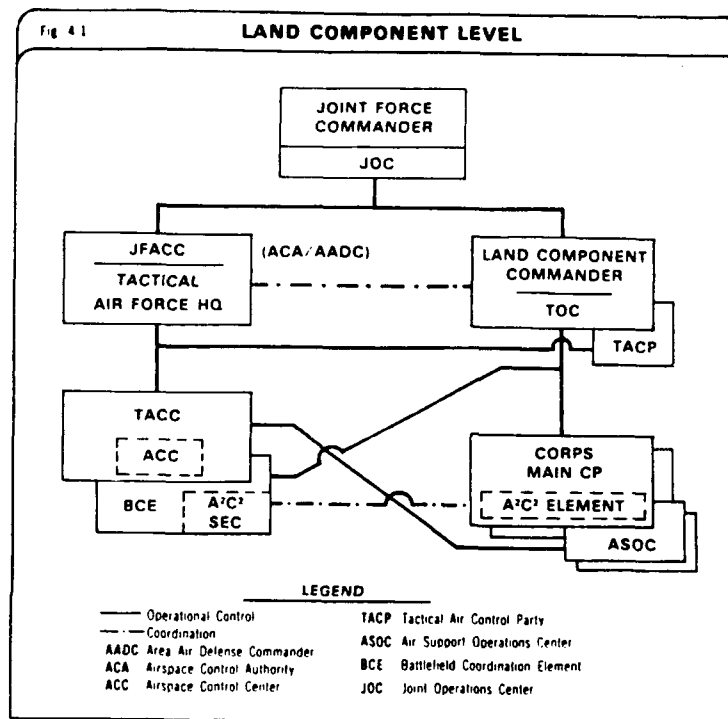
Airspace Control Plan (ACP): Integrates the air defense plan and the fire support plan into the air campaign. It is normally preplanned and in a simple understandable format. It will specify airspace control measures to be used in the area of operations and must plan on degraded command and control systems<sup>13</sup>.

Air Tasking Order (ATO): The ATO tasks assigned and attached units to accomplish specific missions and provides sufficient detail to enable mission aircrews to execute these missions<sup>14</sup>. The Airspace Control Order (ACO) is part of the ATO and is used to update and implement instructions into Airspace Control Plan<sup>15</sup>.

The elements of the airspace control plan must consider interoperability, support of the force, mass and timing, unity of effort, integrated planning cycles and degraded operations<sup>16</sup>. A basic concept is air defense and airspace control is closely coordinated<sup>17</sup>. The Airspace Control Plan must allow for the identification of friendly aircraft without delaying offensive operations and most importantly avoid fratricide.

Methods for controlling airspace range from positive control (electronic means that identify aircraft, radar and IFF/SIF codes)<sup>18</sup> to procedural controls (previously agreed upon airspace control methods)<sup>19</sup>. These procedures are found in FM 100-103 and will not be discussed.

FIGURE 1-



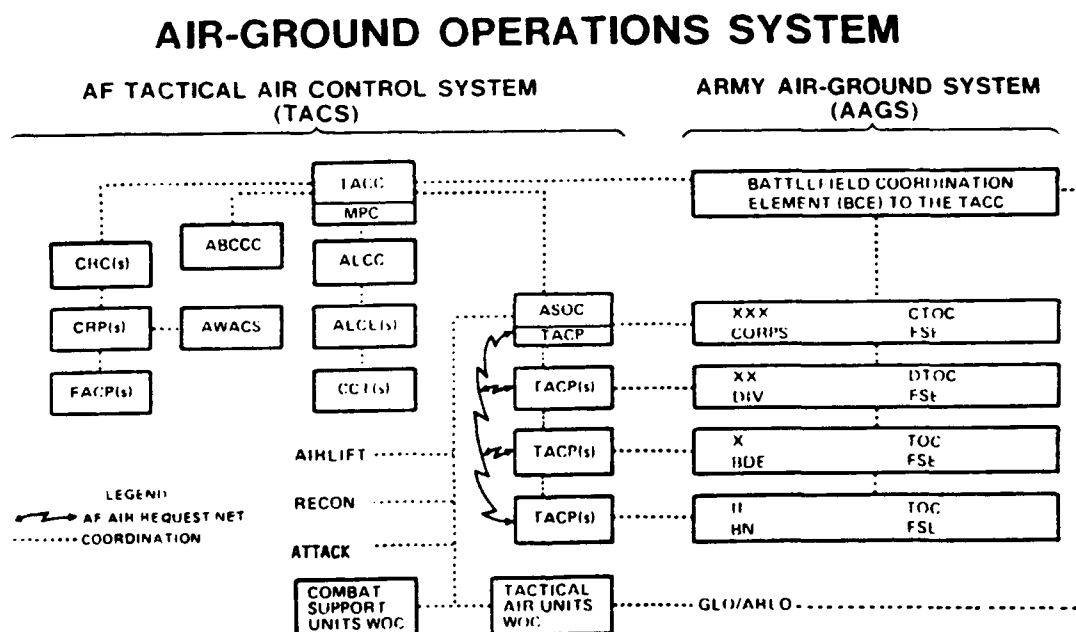
## U.S. Air Force

The Air Force airspace management system is closely tied to the Army Airspace Command and Control (A2C2) system and is found in Air Force Manual 2-7, Tactical Air Force Operations-Tactical Air Control System. The Tactical Air Control System will be traced from the air component commander to the land component commander and corps. Then there will be a brief look at the system down to the forward air controller.

The Tactical Air Control System (TACS) "provides the Air Force Component Commander (AFCC) with elements through which to centrally plan, direct and control tactical operations and to

integrate air operations with other services<sup>21</sup>." The TACS organization is modular and comes with both personnel and equipment. The organization can be tailored for the type force being supported. The Tactical Air Control Center (TACC) is the senior element of the TACS system and is responsible for formulating airspace control procedures, coordinating airspace use and ensuring that the Airspace Control Plan is compatible with current operations. The organization is shown in figure 2. The role and function of each is discussed below;

FIGURE 2<sup>22</sup>



It has the capability to display the air situation in near real time using data from Tactical Air Control System, sensors and air intelligence. The TACC can displace or conduct an airborne role

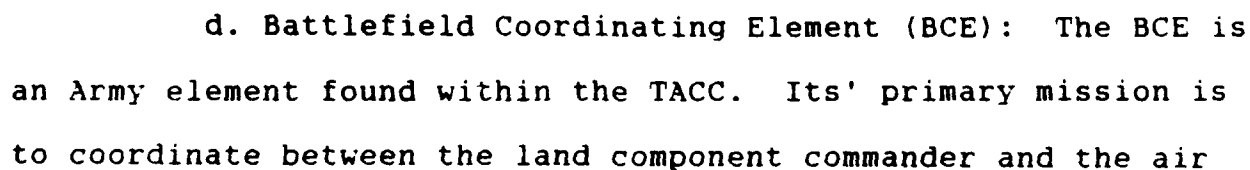
with the Airborne Command and Control Center (ABCCC). The TACC is comprised of four elements and each having sub elements.

a. Control and Reporting Center (CRC): The CRC is a facility that has both radar and communications equipment necessary to conduct the air defense and air traffic guidance of both offensive and defensive missions. This facility can be mobile. The CRC has the capability to relay mission changes to aircraft as well as give directions to other elements of the TACS. It also has the mission to provide threat warnings to friendly aircraft. It has the requirement to coordinate air defense assets from all services to ensure they are employed in a mutually supporting role. As well as coordinating procedures based on friendly artillery fire plans. The CRC can extend its range by employing Airborne Warning and Control System (AWACS) or Control and Reporting Points (CRP). The CRP is identical in organization and is capable of assuming the mission of the CRC. There is the capability to deploy Forward Air Control Posts with mobile radar units that can be used for specific missions, extend range or provide early warning<sup>23</sup>.

b. Airlift Control Center (ALCC): Is responsible for tactical airlift operations and since it does not directly affect airspace management will not be discussed.

c. Air Support Operations Center (ASOC): The ASOC is responsible for the planning, coordinating and directing the tactical air support of land forces maneuver objectives. It is normally aligned with a corps and is physically located within



FIGURE 3<sup>24</sup>

component commander. It does this through six sections shown in figure 3.

1. The PLANS SECTION coordinates the tactical air support required by the land component commander into the Air Tasking Order. The plans section is collocated with the TACC combat plans division and provides the ground campaign plan to the air component commander.

2. The FUSION SECTION is organized to analyze ground component intelligence and friendly situation to assist in the updating of the Air Tasking Order. It is collocated with the enemy situation correlation element of the TACC.

3. The AIR DEFENSE ARTILLERY and ARMY AIRSPACE COMMAND AND CONTROL SECTION's coordinate with the combat plans and operations sections, as well as the corps command post.

4. Coordination with the land component G-2 section is accomplished by the INTELLIGENCE SECTION to obtain the most current reports and collection requirements. It provides information on the enemy order of battle and assists in target development.

5. The OPERATIONS SECTION monitors the execution of the current ATO and coordinates changes. It is collocated with the combat operations division. The section is responsible to know both the current air and ground situations. Battlefield air interdiction missions are monitored and changed as required, as well as keeping the ground component commander updated on mission cancellations or diversions.

6. The AIRLIFT SECTION coordinates airlift support.

The BCE also has liaison officers from each supported corps, as well as from the supporting air wings<sup>25</sup>.

The Tactical Air Control System comes with its own organic communications system and can interface with the Army communications system. The Tactical Air Control Center, including the Battlefield Coordinating Element is tied to the Joint Force Commander by a joint multi-channel system. The Tactical Air Control Center also communicates with the Air Support Operations Center by Air Force multi-channel systems. The Air Support Operations Center communicates with the subordinate Tactical Air Control Parties using either Army multi-channel or organic tactical radios. These nets include the Air Force Air Request Net, Tactical Air Direction Net and the Airlift Advanced Notification/Coordination Net<sup>26</sup>.

#### U.S. ARMY SYSTEM

The Army Airspace Command and Control (A2C2) system is found in FM 100-103, Army Airspace Command and Control in a Combat Zone. It is comprised of three parts that include airspace management elements, air traffic services battalions and air defense artillery units. The A2C2 system interfaces with the Air Force Tactical Air Control System by the Air Support Operations Center, located at the corps command post, as well as the

Battlefield Coordinating Element, located at the Tactical Air Control Center.

a. Airspace Management Elements: The airspace management elements at the corps and division level are called the Corps Airspace Management Element (CAME) and Division Airspace Management Element (DAME) and "are the Army's principle organization charged with the responsibility of airspace control<sup>27</sup>." They are "ad hoc" organizations that come together only when deployed. Because of that, they are normally manned by personnel from other sections within the corps or division command post, there are neither dedicated personnel or equipment authorizations<sup>28</sup>. Both the CAME and DAME fall under the responsibility of G-3 and are supervised by the G-3 Air. These organizations consist of representatives from the air defense element, the fire support element, the aviation element, the Air Force TACP liaison officer, the G-2, the supporting air traffic service battalion, and the G-4. There also could be representatives from the air and naval gunfire liaison company if required. The responsibilities of the airspace management element are as follows;

1. Identify and resolve airspace user conflicts. This includes artillery, aviation, air defense units, as well as the close air support and battlefield air interdiction missions.

2. Maintain overlays and maps. Information for these maps and overlays comes from current and planned operations, as well as the Air Tasking Order.

3. Develop A2C2 procedures and plans using the Airspace Control Plan.

4. Coordinate and integrate airspace user requirements.

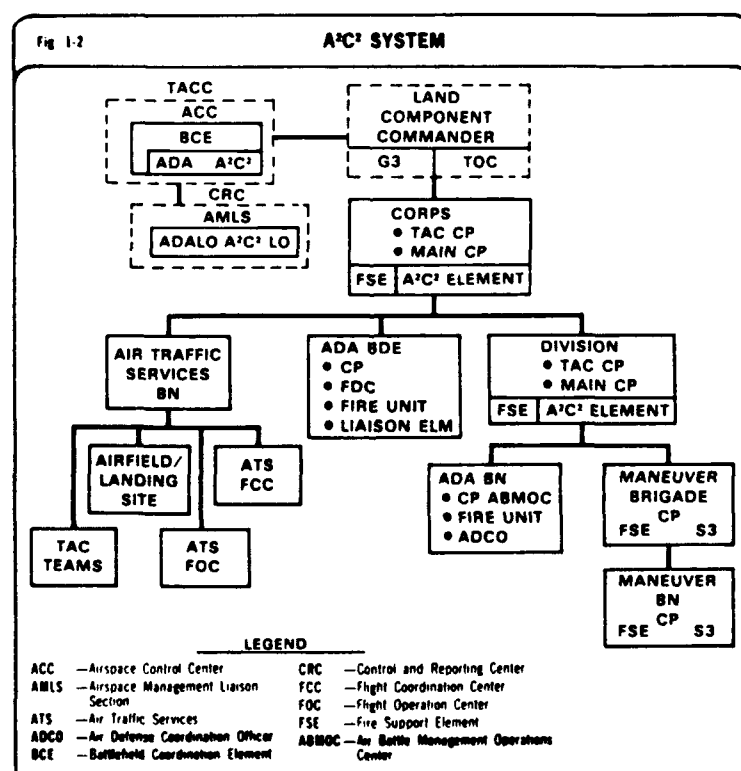
5. Coordinate airspace use with other services within the joint command.

6. Advise subordinate and higher headquarters of significant activities affecting airspace use.

7. Advise subordinate and higher headquarters of the impact of airspace control measures or restrictions on the ground battle.

8. Approve or staff requests for special use airspace<sup>29</sup>.

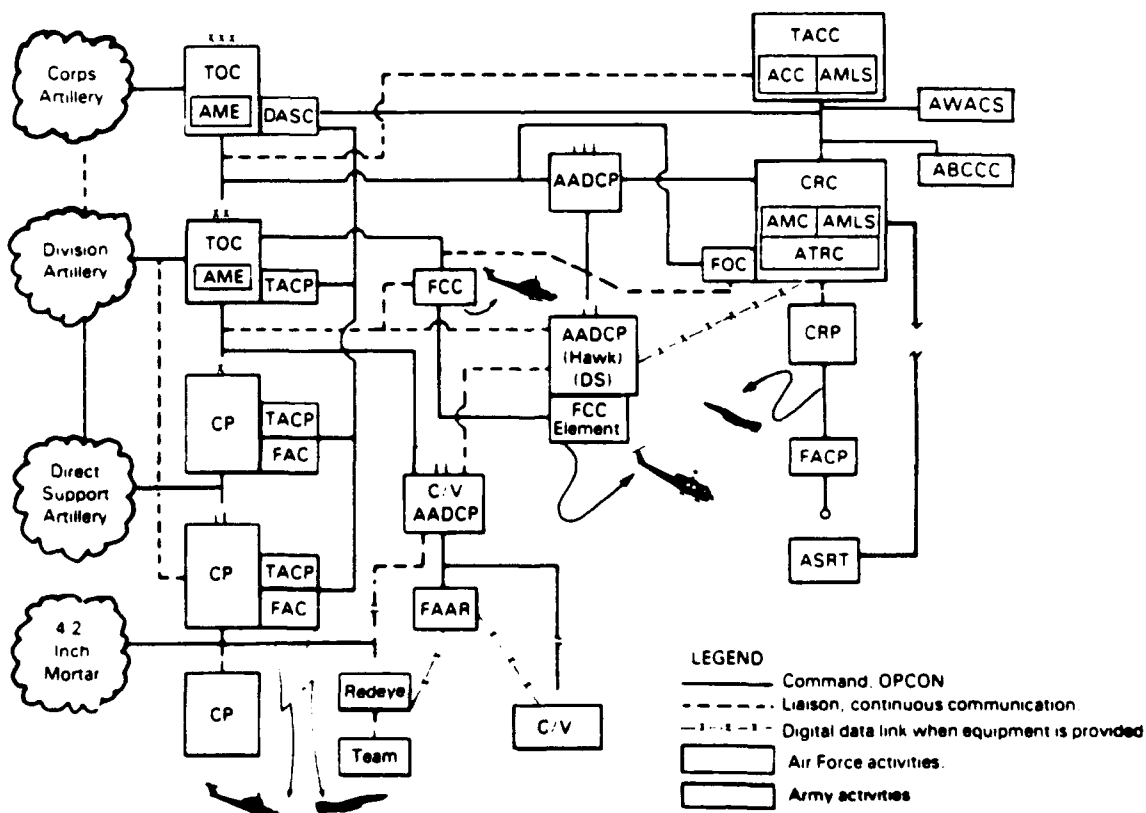
FIGURE 4<sup>30</sup>



The brigades and battalions within the division form their A2C2 elements from the S-3 section using the fire support officer, the air defense liaison officer, the aviation liaison officer and the Air Force TACP. Their functions are much the same as the CAME or DAME<sup>31</sup>.

b. Air Traffic Services Battalions: Each corps is normally assigned an air traffic services battalion that is in direct support of the corps aviation brigade<sup>32</sup>. The air traffic services battalion is designed to provide the corps with terminal and enroute air traffic control support, as well as provide liaison personnel to the airspace management system. Figure 5 helps show this.

FIGURE 5<sup>33</sup>



The battalion does this as follows;

1. The establishment of precision and non-precision instrumented approaches to airfields within the corps and division represents the most important part of the mission. Ground controlled radars, nondirectional beacons and tactical air traffic control towers are used to accomplish this. Although this requirement is important, it represents only a small portion of the airspace management system<sup>34</sup>.

2. As part of the enroute system, the air traffic services battalion installs Flight Operations Centers (FOC) and Flight Coordination Centers (FCC) in both the corps and division area. The FOC/FCC's are responsible to follow aircraft movements, coordinate penetration of the coordination altitude, pass air warnings, receive flight information from aircraft, hand off aircraft to terminal facilities, pass Instrument Flight Rules and Visual Flight Rules flight plans and receive intelligence from aircraft. The FOC is normally collocated with the Air Force Control and Reporting Center or electronically connected to it. It is imperative that the FOC/FCC have access to the ATO and know what the Air Force is doing in a timely manner. Therefore, it is also connected to the CAME and FCC by radio and multi-channel communications. The FCC can communicate with the DAME as well as the FOC. The FCC is also required by doctrine to have an element located at the direct support air defense artillery battalion<sup>35</sup>.

3. The final contribution the Air Traffic Services Battalion makes to the A2C2 plan is liaison teams that are attached to the corps and division airspace management elements.

c. Air Defense Units: The Army air defense command is the final part of the system. The air defense command is electronically connected to the corps command post as well as to the Control and Reporting Center and the Flight Operations Center. Division air defense units are electronically connected to the FCC and the Division Airspace Management Element<sup>36</sup>.

#### U.S. MARINE CORPS

The Marine Corps Air Command and Control System (MACCS) is found in FMFM 5-1, Marine Aviation. It is a coordinated and integrated system that is divided into air defense and air support operations. Like the Air Force system, the controlling agency is the Tactical Air Command Center (TACC). The TACC also provides "the marine tactical commander the means to coordinate organic aircraft with that of other services<sup>37</sup>." This organization is resourced with equipment and personnel from the Marine Air Group and communications equipment from the Marine Wing Communications Squadron<sup>38</sup>.

The TACC is responsible for the following;

- a. Maintain information on the air situation and the ground combat situation as it applies to air support.
- b. Manage all aircraft in the combat area.
- c. Serve as a point of contact for other air support.





intercept and destroy any air threat. A very important role is the control of air defense artillery. The antiaircraft operations center that controls the organic Hawk missiles come under the direction of the TAOC<sup>41</sup>.

b. The Direct Air Support Center is responsible for aircraft that directly support ground operations. It "coordinates close air support strikes, assault support and air reconnaissance missions that require coordination with fire support means, and disseminates friendly and enemy aircraft information<sup>42</sup>." This is accomplished by using surveillance radars organic to the TACC. It also works closely with the fire support coordination center that is controlling indirect fires. The DASC also controls the tactical air control parties that are forward air controllers located with the combat maneuver units<sup>43</sup>.

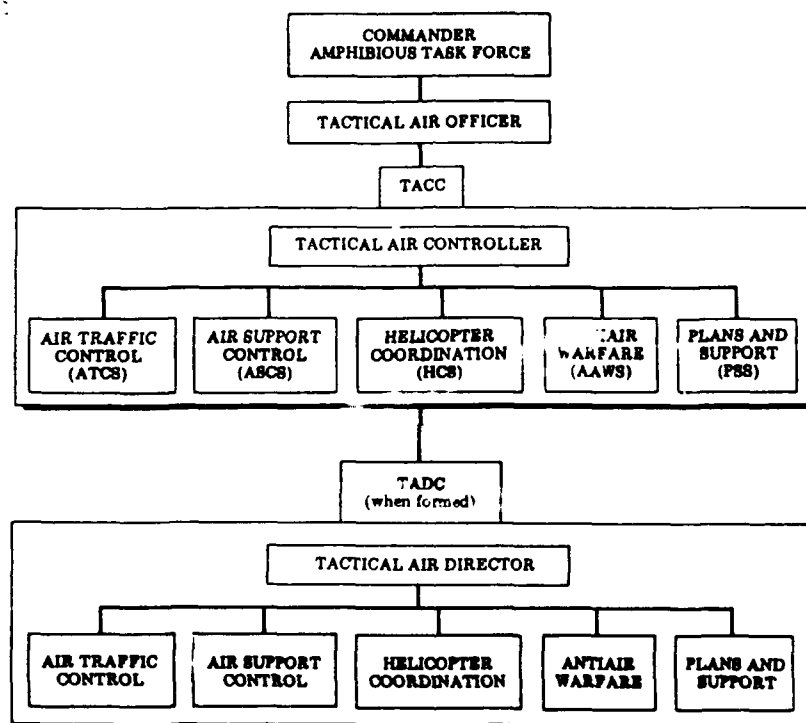
#### U.S. NAVY

The Amphibious Tactical Air Control System (ATACS) is the navy equivalent to the other services' airspace management systems. The ATACS as defined in NWP 22.2, Supporting Arms in Amphibious Operations, is made up of two separate but similar subsystems. The Navy Tactical Air Control System (NTACS) is afloat and the marines' MACCS supports operations ashore. It is important to realize that during an amphibious operation control will start afloat and remain there until transferred to the

landing force. It is possible for the NTACS to control a joint operation that is striking either a land or floating target.

The primary control agency is the Tactical Air Control Center that is responsible for air support and anti-air warfare. Anti-air warfare is defined as use of fighters, attack aircraft, surface to air missiles and antiaircraft artillery<sup>44</sup>. The functions of the Tactical Air Control Center are as follows;

FIGURE 7<sup>45</sup>



1. Ensure an integrated air defense for ships and troops.
2. Provide close air support for units in contact.
3. Consolidate and coordinate air support missions; supply the latest intelligence.
4. Exercise coordination and control of air traffic in the area of operations.

5. Provide an air support coordinator to advise the fire support coordinator of the close air support aircraft available<sup>46</sup>.

The TACC is organized into the five sections shown in figure 7. They are the air traffic control section, the air support control section, helicopter control section, anti-air warfare section, and the plans and support section. Equipment and personnel are authorized and allocated for these functions.

The system ashore has been explained under the Marine Corps section.

#### ANALYSIS

Each service has designed an airspace management system that it feels will meet its own unique needs. But the complex threat that the world presents to the United States today and the reduction in defense spending will force the increased reliance on joint operations to guarantee success. The demand for use of the airspace above the battlefield will only increase as technology improves. Weapons systems and aircraft are increasing their range and accuracy. Intelligence systems such as JSTARS and remotely powered vehicles allow commanders to look deeper into the enemies' rear area and give him the ability to influence the battle from a greater range in both time and space. This will only complicate the airspace management process and demand more coordination.

What does this increased reliance on joint operations really mean when applied to airspace management? In the past airspace has been divided into blocks attempting to limit each service to its own area. One example would be using a coordination altitude that restricts helicopters to remain below it and fixed wing aircraft to remain above. This would effectively separate Army and Air Force aircraft. Another example would be assigning different lateral boundaries between Army and Marine units that would separate the airspace above it. The Army now has weapons that can strike deep into what was once considered the battlefield air interdiction area. Both the multiple launch rocket system (MLRS) with ATACMS, and the AH-64 Apache attack helicopter have extended ranges that far exceed normal tube artillery. The modern battlefield will use multiple types of aircraft for close air support, flying faster and in a different engagement envelope. They will use high-tech munitions that demand different tactics to defeat improved armor. It will no longer be possible for each service to operate independently.

Control of this airspace will have to be joint. JOINT PUB 3-52 will establish that. It recognizes that future operations will have to be joint and this will require one joint forces commander. It also recognizes the need for one air component commander responsible for the execution of the air campaign. The recent success of the air campaign during Desert Storm would certainly appear to support this. This responsibility includes every type of weapon or surveillance system that uses the

airspace. This document establishes that Joint Force Air Component Commander is not only responsible for air operations, but also for air defense and establishing an airspace control plan. There must be the means to control with both communications equipment and procedures. It also will establish the requirement for any use of the airspace to be coordinated through the Airspace Control Authority<sup>47</sup>. Since the document is still in draft it is important that words such as will and must are used. If they are not and words such as shall and can replace them then the document will have been diluted. Service parochialism and fear of losing control of assets are not valid reasons to degrade this combat potential. Joint operations are the only way to maximize combat assets during a time of shrinking resources.

A review of each service's system show that the Air Force, Navy and Marines all are similar. They are built around a Tactical Air Control Center. Although the physical layout and equipment may differ, all are designed to control aircraft and coordinate the use of the airspace. While these systems may appear simple in a wiring diagram, they are actually very equipment and personnel intensive. The operation of radars and communications equipment that extend from the theater rear to the forward air controllers is complex. It is very important to remember that resources, both people and equipment must be dedicated to control airspace properly.

While three services have systems suitable for joint airspace management and control, it is important to make several observations. First, the Navy system will most likely be used only in joint operations that are projecting air power ashore for a short period of time. More than likely this would be aircraft from an aircraft carrier battle group supported by Air Force attack aircraft or Army helicopters, for a strike mission of short duration with a limited objective. The other use would be support of an amphibious operation with control of the airspace passing ashore as soon as the means to control it was established. The Marine system is by far the cleanest, having all the users of the airspace together under one command. The Marine Expeditionary Force commander has both the air and ground elements under his command. The Marines have also assigned the air defense artillery mission to the air component commander. This includes operational control of the air defense weapons. They also have tactical air control parties down to the battalion level with the mission to coordinate the airspace as well as control close air support missions. Clearly the Air Force has the system that can expand and absorb the most aircraft. It is also extremely flexible with the Airborne Command and Control Centers that can provide mobile and forward control.

JOINT PUB 3-52 defines the Joint Forces Air Component Commander as the commander of the service contributing the largest portion of the air assets. The current version of the DRAFT 3-52 lists only the Air Force, Navy and Marines as

potential JFACC's<sup>43</sup>. The next revision will add the Army to that list, citing "Operation Just Cause" in Panama as an example of the Army contributing the largest number of aircraft<sup>43</sup>. While this may have been true, the Army does not have the airspace management system to coordinate and control high performance aircraft.

The Army has done an excellent job of documenting how airspace management must be worked into an operation. There are literally dozens of publications that address the subject. FM 100-103 is full of information on how A2C2 elements must coordinate both laterally and vertically. What it has not done well is to resource the A2C2 system with people and equipment, nor to train the users properly. There is neither an established A2C2 organization, nor is there dedicated equipment. The only organization resourced with personnel is the Battlefield Coordination Element, located at the Air Force Tactical Air Control Center. Virtually no echelon above corps A2C2 exists except for one Air Traffic Control Group Headquarters in the reserves. According to FM 100-16 this headquarters would have command and control of all ATS battalions in the Theater<sup>50</sup>.

The primary facility for airspace management is the Corps Airspace Management Element. As described earlier, this is a group of people who come together from different staff elements during training exercises or a deployment. The Corps Airspace Management Element has neither dedicated equipment nor a dedicated means of communications to other A2C2 elements. The



CAME is the critical link in the interface between the corps and the Air Force. This is the facility within the corps command post that receives the ATO. It can coordinate with either the Air Support Operations Center at the corps or the Battlefield Coordination Element at the Tactical Air Control Center. The Air Support Operations Center has its own redundant microwave system and high frequency radios to stay in contact with the Tactical Air Control Center. The corps also has a Tactical Air Control Party that is responsible for the coordination of air support. The interface of these three organizations is critical to establishing effective use of the airspace. The Division Airspace Management Element falls into the same category as the Corps Airspace Management Element, but only has access to the communications' facilities that are found in the Tactical Air Control Party.

Use of airspace must be approved by the Joint Force Air Component Commander and the Airspace Control Authority. This includes artillery fire, air defense weapons status that vary from the Airspace Control Authority, strikes beyond the Fire Support Coordination Line (FSCL) and any penetration of the coordination altitude. This requires the tactical planners to keep the A2C2 element included in both future and current operations. A brigade commander who has been given a mission to seize an objective and defend it cannot create a high density air defense zone around his area without coordinating that through the Airspace Control Authority. Neither can a corps commander

decide to strike a deep target with MLRS without coordinating the operation. Failure to do either could result in fratricide. In order for this coordination to take place there must be a responsive system in place that is exercised and used. A system that includes people, equipment, and procedures.

The Flight Operations Center and Flight Coordination Center that interface with the Control and Reporting Center, the corps command post, the division command post and the direct support air defense artillery units have very limited capability. They have no organic multichannel or hard copy capability and are dependent on the corps and division communications systems. By doctrine, the Air Force is responsible for providing the communications link between the CRC and the FOC<sup>51</sup>. This responsibility could place the FOC in a position that was advantageous for Air Force communication requirements but not for Army needs. The FOC has no radar capability and the radios are limited to line of sight aviation family radios<sup>52</sup>. Both equipment and personnel limit its' capability. The FCC, identical to the FOC in equipment, is supposed to provide a liaison team to the division direct support ADA battalion and a liaison team to the DAME. The FOC is required to provide a liaison team to the CRC. But, neither organization has the people assigned to it to accomplish those missions.

LTC Cross and LTC Nelson's paper, Adequacy of the Army Airspace Command and Control System on the AirLand Battlefield, makes several valid points on the Army A2C2 capabilities. The

resourcing of the A2C2 cells at both the division and corps is inadequate for 24 hour operations. There is a general lack of knowledge on the system, the leaders are not properly trained, and perhaps most important, the equipment is not adequate<sup>53</sup>.

The primary document that implements the airspace management plan is the Air Tasking Order. Part of the ATO is the Airspace Control Order<sup>54</sup>. The ATO amends the Airspace Control Plan and is updated each eight hours. The ATO is a lengthy document that works on a 72 hour cycle. At any time the Tactical Air Control Center is working on three ATO's. The cycle is time consuming because the Joint Force Commander, the Land Component Commander and Joint Force Air Component Commander must develop the guidance and determine what amount of effort will go into close air support, air interdiction including battlefield air interdiction, and counterair. From this they develop the apportionment of air resources. Apportionment is defined as the determination and assignment of percentage of effort that will be dedicated to air operations and units<sup>55</sup>. An example would be allocating 40% of the total sorties to close air support and 50% of that total going to each corps. At the 48 hour point the Land Component Commander will know what portion of the air effort will be received and the Battlefield Coordination Element will work with each corps planning targets. They also will know what portion of the Air Interdiction missions will be dedicated to Battlefield Air Interdiction.

At 36 hours the publication of the ATO begins. At 30 hours the corps provides the Battlefield Coordination Element with their prioritized target nominations. The 24 hour point is where the ADA/A2C2 section of the Battlefield Coordination Element coordinate airspace matters with the Tactical Air Control Center. At the 12 hour mark the ATO is published. This is a very time consuming and bulky document when it is finished. It has all the pertinent airspace control procedures included. These could be low level transient routes, standard use army aircraft flight routes, base defense and weapons free zones as well as high density air defense zones. All of these impact on how the commander will use his airspace. These airspace procedures cover the entire joint area of operations.

Normally, the lowest level the ATO makes it to is the ASOC. This gives very little time for the information to get below the corps level. Is this important? The answer is yes. Because the planning cycle is so long for the ATO that it is quite possible, even likely, that the tactical situation will have changed. It is important for the tactical commander at division and below to know what air operations are planned in his area for two reasons. He could be planning an assault or operation using artillery, air defense weapons, or aviation that will penetrate the coordination altitude. Conflicts would require him to either change his operation or send directions through the A2C2 cells to divert air missions. Or, he could be unaware of Air Force targeting being

conducted in his area of interest that could affect future operations.

The problem appears to be in two parts. First the planning cycle is too long and second the actual plan does not always reach the people who need it.

### CONCLUSIONS

There must be a joint airspace system, as discussed earlier. The best way for the United States military to execute future operations, during a period of steadily declining resources is by massing combat power through joint operations. Desert Storm serves as an excellent example. A hard look must be taken at parochial roles. Such as the role of Navy and Marine aircraft. Joint operations will require not only doctrine but also compatible equipment and procedures. The Air Force, Navy and Marines have systems in place that will support joint operations. All have basically the same organization that builds from a Tactical Air Control Center. An effort should be made to standardize terms among the services. Although this paper did not look at the type of equipment each service uses, it should be compatible with all types of aircraft in the system, as well as ground communications. An effort must be made to make command and control systems of the services not only compatible but interchangeable.

The Army will have to become more integrated into these systems. It is quite clear that there is a dramatic increase in

the number of weapons that have far greater range and depth. This increase in range will require more coordination to optimize the weapons potential. The standard procedures and roles will have to be relooked, such as the fire support coordination line that may be pushed out so far that it is in the battlefield air interdiction zone. The Air Force can no longer say that artillery cannot be controlled and does not pose a threat to aircraft<sup>16</sup>.

The Army A2C2 system needs to be reworked. A system that is built on organizations that do not have people, equipment or standard operating procedures cannot be effective. The doctrine exists, as well as the requirement for the functions. What is required is an organization that will parallel the Air Force Tactical Air Control System. The Marine airspace management system may well prove an excellent model. There is too much reliance on liaison teams that come out of the hide of the operational aviation units and "ad hoc" airspace management elements. Any problem can be fixed by adding more people and new equipment to the responsible organization and function. The Department of the Army does not have the resources available to fix every problem or shortcoming that exists. In these times of reduced resources priorities must be established. Some missions can be transferred to the reserve components based on what level they support.

Emphasis needs to be put on A2C2 operations at the tactical level and on air traffic services at the operational level. The

role as well as capabilities of air traffic service organizations must be relooked. This includes theater army A2C2 requirements. Does the Army need an air traffic services group headquarters or does it need an Echelon Above Corps A2C2 element? The Flight Operations Center/Flight Coordination Center concept is not effective. The communications equipment does not have the range to provide the coverage needed especially at low altitudes. As Army systems reach further out into the battlefield the old procedures will be less effective. In this age of automation a very hard look must be taken at the communication requirements for passing airspace management data. This includes tying into the Air Force system to receive the ATO's.

The next point is the requirement for the army to provide better training for those individuals required to perform A2C2 missions. That does not mean that the Army has to create another school. What it does mean, is to take advantage of schools that already exist, such as the Air Force Air Ground Operations School at Hurlbert Air Field. Individuals attending A2C2 schools need to be identified with a specialty code. Airspace management must be worked into training exercises at all levels. This should start at the small unit level and go through to the National Training Center level. It must include integration with the Air Force TACS and the ATO.

The Air Tasking Order system needs to be reevaluated. A 72 hour planning cycle is very difficult to work with. Although it may work well for counterair and air interdiction operations it

is very difficult for the ground commander to forecast battlefield air interdiction and close air support within the time frame of the ATO planning cycle of 18 to 24 hours. The final order is published at the 12 hour point, this makes it very difficult to get the portions that affect the ground commander out. It may be necessary to reformat the order or take advantage of the automation that exists.

The Army does not have the means to control other service aircraft except in the close air support arena. It would be very difficult for an Army aviator to serve as the Joint Force Air Component Commander without using another service's Tactical Air Control Center. As we look at more joint operations this does not seem to be a serious problem.



## GLOSSARY

A2C2	Army Airspace Command and Control
AADC	Area Air Defense Commander
ABCCC	Airborne Command and Control Center
ACA	Airspace Control Authority
ACP	Airspace Control Plan
ACO	Airspace Control Order
ADA	Air Defense Artillery
AFCC	Air Force Component Commander
ALCC	Air Lift Coordination Center
ASOC	Air Support Operations Center
ATACS	Amphibious Tactical Air Control System
ATACMS	Army Tactical Missile System
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
BCE	Battlefield Coordination Center
CAME	Corps Airspace Management Element
CRC	Control and Reporting Center
CRP	Control and Reporting Point
DAME	Division Airspace Management Element
DASC	Direct Air Support Center
FCC	Flight Coordination Center
FOC	Flight Operations Center
FSCL	Fire Support Coordination Line
IFF	Identification Friend or Foe
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JSTARS	Joint Service Tactical and Attack Radar System
LCC	Land Component Commander
MACCS	Marine Corps Air Command and Control System
MEF	Marine Expeditionary Force
MLRS	Multiple Launch Rocket System
NTACS	Navy Tactical Air Control System
SIF	Selective Identification Feature
TACC	Tactical Air Control Center
TACP	Tactical Air Control Party
TACS	Tactical Air Control System
TAOC	Tactical Air Operations Center

1. U.S. Department of the Army, Field Manual 100-103, p. 52-53. (hereafter referred to as FM 100-103)
2. BG Rudolph Ostavich III, U.S. Army Aviation Digest, Vol 32, Number 11, November 1986, p. 2.
3. Clay Blair, Ridgway's Paratroopers, p. 101-102.
4. Chaim Herzog, The Arab-Israeli Wars, p. 311.
5. Mark Adkins, Urgent Fury: The Battle for Grenada, p. 260.
6. Ibid., p. 160, 286, 336, 337.
7. U.S. Department of Defense, FM 100-28, AFM 1-3, NWP 17, LFM 04, p. 1-1. (hereafter referred to as FM 100-28)
8. Title 10, U.S. Code, as amended by DOD Reorganization Act of 1986.
9. FM 100-28, p.1-3.
10. Office of the Joint Chiefs of Staff, JOINT PUB 3-53 (DRAFT), p. I-4. (hereafter referred to as JOINT PUB 3-52)
11. Ibid., p. 1-5.
12. Ibid., p. II-5-7.
13. Ibid., p. II-7.
14. U.S. Department of the Army, TRADOC PAM 525-45, p. 5-1.
15. Interview with Steve Pittoti, MAJ USAF, U.S. Department of the Air Force, Air Force Doctrine, Washington: 4 February 1991. (hereafter referred to as Interview Maj Pittoti)
16. JOINT PUB 3-52, p. III-3.
17. U.S. Department of the Air Force, Air Force Manual 2-7, p. 2. (hereafter referred to as AFM 2-7)
18. FM 100-103, p. Glossary-8.
19. Ibid.
20. Ibid., p. 4-2.
21. AFM 2-7, p. 2-1.
22. U.S. Department of the Air Force, TAC Regulation 55-46, p. 1-4. (hereafter referred to as TAC REG 55-46)

23. U.S. Department of the Air Force, TAC Regulation 55-45, p. 5-2.
24. FM 100-103, p. 4-3.
25. U.S. Department of the Army, Field Manual 100-15, p. F-2.
26. TAC REG 55-46, p. 1-3.
27. FM 100-103, p. 4-6.
28. Ibid., p. 4-6.
29. Ibid., p.4-8.
30. U.S. Department of the Army, Field Manual 100-42, p. 3-2.  
(hereafter referred to as FM 100-42)
31. Ibid., p.5-17.
32. U.S. Department of the Army, Field Manual 1-111, p. 3-13.
33. FM 100-103, p. 1-15.
34. U.S. Department of the Army, Field Manual 1-103, p. C-3.  
(hereafter referred to as FM 1-103)
35. FM 100-42, p. 3-2.
36. Ibid.
37. U.S. Department of the Navy, Fleet Marine Field Manual 5-1, p.  
47. (hereafter referred to as FMFM 5-1)
38. Ibid., p. 47.
39. Ibid., p. 49.
40. Ibid., p. 48.
41. Ibid., p. 50.
42. Ibid., p. 53.
43. Ibid.
44. U.S. Department of the Navy, Naval Warfare Publication 22.2, p.  
4-5. (hereafter referred to as NWP 22.2)
45. NWP 22.2, p. 4-4.
46. FMFM 5-1, p. 4-6.

47. JOINT PUB 3-52, P. II-5.
48. Ibid., p. II-3.
49. Interview Maj Pittoti.
50. U.S. Department of the Army, Field Manual 100-16, p. 4-7.
51. FM 1-103, p. B-7.
52. Ibid., p. B-12.
53. Dennis D. Cross, LTC and Wayne T. Nelson LTC, Adequacy of the Army Airspace Command and Control System on the AirLand Battlefield, p. 51-59.
54. Interview Maj Pittoti.
55. U.S. Department of the Army, Field Manual 101-5-1, p. 1-5.
56. U.S. Department of the Air Force, Air Force Manual 2-12, p. 13.

## BIBLIOGRAPHY

1. Ackerman, Michael W. LTC, et al. U.S. Army Counterair Operations. Carlisle Barracks: U.S. Army War College, 23 March 1983.
2. Adkin, Mark. Urgent Fury: The Battle for Grenada. Lexington, Mass.: Lexington Books, 1989.
3. Bielfeld, William C. MAJ. Air Interdiction: Will it Support AirLand Battle? Fort Leavenworth: School of Advanced Military Studies, 16 May 1986.
4. Chandler, Edward D. LTC. Aviation Liaison Officers: A Means to Enhance Combat Power. Carlisle Barracks: U.S. Army War College, 31 March 1989.
5. Cross, Dennis D. LTC, Wayne T. Nelson LTC. Adequacy of the Army Airspace Command and Control System on the AirLand Battlefield. Carlisle Barracks: U.S. Army War College, 2 April 1990.
6. Curren, John M. MAJ. Air Support for AirLand Battle. Fort Leavenworth: School for Advanced Military Studies, 16 May 1986.
7. Mullendore, Lauren G. MAJ. The Future of the Joint Air Attack Team in the AirLand Battle. Maxwell Air Force Base: Air University, May 1989.
8. Ostavich, Rudolph III BG. "AirLand Battle-Part I: Dramatic Changes in Emerging Aviation Doctrine." U.S. Army Aviation Digest Vol 32, Number 11, November 1986, pp.2-7.
9. Shrader, Charles R. LTC. Amicide: The Problem of Friendly Fire in Modern War. Fort Leavenworth, U.S. Army Command and General Staff College, December 1982.
10. Office of the Joint Chiefs of Staff. Joint Chiefs of Staff Publication 3-01.2: Joint Doctrine for Theater Counter Air Operations. Washington: 1 April 1986.
11. Office of the Joint Chiefs of Staff. Joint Chiefs of Staff Publication 3-01.3: Joint Doctrine for Air Defense: Washington: 23 May 1964.
12. Office of the Joint Chiefs of Staff. Joint Chiefs of Staff Publication 3-01.4 (FINAL DRAFT): JTTP for Joint Suppression of Enemy Air Defenses. Washington: 31 December 1990.
13. Office of the Joint Chiefs of Staff. Joint Chiefs of Staff Publication 3-04. Doctrine for Maritime Operations(Air) (PROPOSED FINAL PUBLICATION). Washington: undated.

14. Office of the Joint Chiefs of Staff. Joint Chiefs of Staff Publication 3-52 (DRAFT). Doctrine for Joint Airspace Control in a Combat Zone. Washington: 6 November 1990.

15. U.S. Department of the Air Force. AF Manual 1-1: Basic Aerospace Doctrine. Washington: 16 March 1984.

16. U.S. Department of the Air Force. AF Manual 2-1: Tactical Air Operations-Counterair, Close Air Support, and Air Interdiction. Washington: 2 May 1969.

17. U.S. Department of the Air Force. AF Manual 2-7: Tactical Air Force Operations-Tactical Air Controller System (TACS). Washington: 2 February 1979.

18. U.S. Department of the Air Force. AF Manual 2-12: Airspace Control in the Combat Zone. Washington: 22 August 1988.

19. U.S. Department of the Air Force. Headquarters U.S.A.F. Air Ground Operation School. Battle Staff Course Workbook. Hurlburt Field: April 1988.

20. U.S. Department of the Air Force. Headquarters Tactical Air Command. TAC Regulation 55-45: Tactical Air Force Headquarters and the Tactical Air Control Center. Langley Air Force Base: 8 April 1988.

21. U.S. Department of the Air Force. Headquarters Tactical Air Command. TAC Regulation 55-46: The Tactical Air Control System (TACS), Air Support Operations Center (ASOC). Langley Air Force Base: 20 April 1988.

22. U.S. Department of the Army. Field Manual 1-100: Army Aviation in Combat Operations. Washington: February 1989.

23. U.S. Department of the Army. Field Manual 1-111: Aviation Brigades. Washington: August 1990.

24. U.S. Department of the Army. Field Manual 1-103: Airspace Management and Army Air Traffic Control in a Combat Zone. Washington: 30 December 1981.

25. U.S. Department of the Army. Field Manual 31-11: Amphibious Operations. Washington: 1 November 1986.

26. U.S. Department of the Army. Field Manual 31-12: Army Forces in Amphibious Operations. Washington: March 1961.

27. U.S. Department of the Army. Field Manual 90-15: Multi-Service Procedures for the Joint Suppression of Enemy Air Defenses. Washington: June 1990.

28. U.S. Department of the Army. Field Manual 90-20: Multiservice Procedures for the Joint Application of Firepower. Washington: July 1989.

29. U.S. Department of the Army. Field Manual 100-5: Operations. Washington: May 1986.

30. U.S. Department of the Army. Field Manual 100-15: Corps Operations. Washington: September 1989.

31. U.S. Department of the Army. Field Manual 100-16: Support Operations. Washington: April 1985.

32. U.S. Department of the Army. Field Manual 100-28: Doctrine and Procedures for Airspace Control in a Combat Zone. Washington: October 1975.

33. U.S. Department of the Army. Field Manual 100-42: U.S. Air Force/U.S. Army Airspace Management in an Area of Operations. Washington: 1 November 1976.

34. U.S. Department of the Army. Field Manual 100-103: Army Airspace Command and Control in a Combat Zone. Washington: October 1987.

35. U.S. Department of the Army. Field Manual 101-5-1: Operational Terms and Symbols. Washington: October 1985.

36. U.S. Department of the Army. TRADOC PAM 525-5: Joint Air Attack Team Operations. Fort Monroe: 31 October 1984.

37. U.S. Department of the Army. TRADOC PAM 525-45: General Operating Procedures for Joint Attack of the Second Echelon (J-SAK). Fort Monroe: 31 December 1984.

38. U.S. Department of the Army. TRADOC PAM 525-47: Joint Concept and Procedures for Close air Support in the Rear Battle. Fort Monroe: 8 July 1986.

39. U.S. Department of the Navy. Fleet Marine Field Manual 5-1: Marine Aviation. Washington: 24 August 1979.

40. U.S. Department of the Navy. Naval Warfare Publication 10-2: Strike Operations Against Land Targets (Secret). Washington: undated.

41. U.S. Department of the Navy. Naval Warfare Publication 22-2: Supporting Arms in Amphibious Operations. Washington: undated.